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(54) Polyurethane foam-filled containers and methods of making them.

(57) Disclosed herein is a polyurethane foam-filled container of the type wherein the cavity is filled with polyurethane foam of open-cell structure, characterized in that the foam is filled in compressed state and the compression is effected in the direction of the minor axis of the unit cell constituting the foam. The container is suitable as fuel tanks and ink and paint reservoirs. Also disclosed herein is a method for filling polyurethane foam into a container.

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The present invention relates to a container filled with polyurethane foam in a compressed state to store and supply a liquid such as fuel, paint, or ink, said container having a cavity capable of uniformly storing, holding, and discharging a liquid.

The present invention also relates to a method for filling a liquid container with polyurethane foam in uniformly compressed state.

Conventional containers holding fuel or other liquid pose a problem when they are in motion during use. The problem is associated with the movement of the liquid to one end of the cavity, which changes the center of gravity of the liquid and causes sloshing. They also have a disadvantage that the discharging rate of liquid (e.g., fuel) varies depending on the amount of liquid in the cavity. To address this problem, there has been proposed a means to prevent the movement of liquid in the cavity by filling the cavity with polyurethane foam of open-cell structure. (See US-A-4771295)

According to the disclosed prior art technology, the cavity of a container is filled with polyurethane foam of open-cell structure, so that liquid is stored in the cells of the foam. This arrangement prevents the liquid from moving bodily in the cavity even when the container is in motion, and also permits the liquid to be discharged uniformly irrespective of the amount of liquid in the container.

However, the prior art technology still suffers from a disadvantage in that the foam cells in the cavity do not hold the liquid steadily but permit the liquid to move in the foam when the container is in motion. Moreover, the foam cells do not ensure the uniform discharging of the liquid.

The general problem addressed herein is to provide novel foam-filled containers and methods of making them.

A preferred aim is to improve the liquid-holding characteristics of such a container.

The present invention is embodied in a polyurethane foam-filled container of the type wherein the cavity is filled with polyurethane foam of open - cell structure, characterized in that the foam is filled in the compressed state and the compression is effected substantially in the direction of the minor axis of the unit cell constituting the foam.

The polyurethane foam used in the present invention is flexible polyurethane foam, which may vary in physical properties, cell size, and compression ratio depending on the kind of the liquid to be held in the container.

The polyurethane foam desirably has a cell number of 20 to 100 per inch, preferably 30 to 60 per inch(8 to 40 per cm, preferably 12 to 24 per cm), a density of 0.010 to 0.070 g/cm^3, preferably 0.020 to 0.040 g/cm^3, a void volume of 93 to 99%, preferably 96 to 98%. The foam compression ratio should be 1/1 to 1/10, preferably 1/2 to 1/10, more preferably 1/2 to 1/5.

kg/m^3 refer 10 kg/m^3

If the cell number is below 50/inch (20/cm), the preferred compression ratio is 1/2 to 1/10. If the cell number is higher than 50/inch, the preferred compression ratio is 1/1 to 1/5, more preferably 1/2 to 1/5.

The polyurethane foam specified above may have cell membrane unremoved. However, polyurethane foam of open cell structure with no cell membranes is preferable. An open-cell polyurethane foam (or reticulated polyurethane foam) with no cell membranes may be obtained by any known method, including the dipping of foam in an aqueous alkaline solution or the breaking of cell membranes by explosion.

The polyurethane foam is filled into the cavity of the container in such a manner that the foam is compressed in the direction of the minor axis of the unit cell. This compression may be accomplished mechanically or thermally for permanent deformation.

We have found that when the polyurethane foam filled into the cavity of the container is compressed in the direction of the minor axis of the unit cell, it is possible to achieve a stronger capillary action than with foam which is merely filled into the cavity without compression. The stronger capillary action reduces the movement of liquid in the cavity when the container is in motion and yet permits liquid to be discharged uniformly.

Since individual cells of polyurethane foam are generally oval rather than spherical, as seen by microscopic observation, the polyurethane foam will produce uneven capillary action if it is compressed in the direction of the major axis of oval. The uneven capillary action hinders the uniform discharging of liquid. Therefore, it is necessary to compress the polyurethane foam uniformly by performing compression in the direction of the minor axis of the unit cell.

The liquid container filled with polyurethane foam, which is compressed in the direction of the minor axis of the unit cell as mentioned above, offers the following advantages. Compression brings individual cells close together so that individual cells produce a stronger capillary action which helps the polyurethane foam to hold liquid stably even when the container is in motion. The compressed polyurethane foam prevents the rapid leakage of liquid when the container is broken. This contributes to safety.

Polyurethane foam-filled containers of the present type may find use as a fuel container (for gasoline), ink container (for office machines), or paint container. The compressed polyurethane foam in the container enables storage and smooth discharge of liquid owing to the capillary action of the foam. It will also find use for other purposes, owing to its characteristic properties.

For the polyurethane foam-filled container to exhibit its full effect as mentioned above, it is desirable to carry out compression in a specific manner. Simple compression may well result in uneven compression that appears as streaks, and these streaks cause liq-

uid to flow along them.

We have been able to achieve good results by a first step of compressing polyurethane foam in a certain amount along guides in the direction of the minor axis of the unit cell, and a second step of moving the compressed polyurethane foam in the direction vertically perpendicular to the direction of compression in the first step, thereby filling the compressed polyurethane foam into a container along guide pieces on the inner wall of the container.

The above-mentioned method may advantageously be modified such that the first step is followed by an additional substep of slightly adjusting the amount of compression in the direction horizontally perpendicular to the direction of compression in the first step.

Guide and guide piece desirably have low-friction surfaces e.g. a coating layer of a resin having a low coefficient of friction, and a preferred example of the resin is a fluoroplastic.

The above-mentioned method is intended to specify the direction of compression, thereby filling a container with a compressed polyurethane foam which is completely free from wrinkles. In other words, it specifies the direction and sequence of compression and pushing to facilitate the filling of the foam into a container. Thus the method of the described above permits polyurethane foam to be uniformly filled into a container.

According to the method as described, the filling of polyurethane foam into a container is accomplished by two steps which differ in the direction of compression and pushing. This method is effective in the uniform filling of polyurethane foam into a container. The resulting polyurethane foam-filled container may be used as a fuel container, in which case the fuel is relieved from vigorous sloshing and the fuel is discharged smoothly at a constant rate.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partly cutaway perspective view showing a fuel container;

Fig. 2 is a fragmentary sectional view showing a reticulated polyurethane foam;

Fig. 3 is a fragmentary sectional view showing the polyurethane foam in compressed state;

Fig. 4 is a perspective view showing a jig used for compressing polyurethane foam in one embodiment of the present invention;

Fig. 5 is a side view showing how the final step of the first embodiment is carried out;

Fig. 6 is a perspective view showing a jig used for compressing polyurethane foam in a second embodiment of the present invention; and

Fig. 7 is a side view showing how the jig shown in Fig. 6 is used in the final step of the second embodiment.

DETAILED DESCRIPTION

Fig. 1 is a partly cutaway perspective view showing a fuel container as an example of the container pertaining to the present invention. Referring to Fig. 1, there are shown a container proper 1, an inlet 2 (for gasoline or the like), an outlet 3, and a cavity 4. The cavity 4 is filled with compressed polyurethane foam 5a.

Fig. 2 is an enlarged fragmentary sectional view showing a polyurethane foam, and Fig. 3 is an enlarged fragmentary sectional view showing the polyurethane foam in compressed state.

The polyurethane foam 5 is a reticulated type, with its cell membranes removed by an explosion method.

The polyurethane foam 5 is compressed in the direction of the minor axis of the unit cell constituting the foam. The minor axis (indicated by "a") and major axis (indicated by "b") of the unit cell can be identified by observing the foam with a magnifier. In general, the direction of the major axis (b) coincides with the direction in which the polyurethane foam expands from the liquid raw material in the foaming process, and the direction of the minor axis (a) is perpendicular to the direction of the major axis (b). Compressing the foam in the specified direction is an important feature.

The filling of compressed polyurethane foam into the cavity of the container is accomplished in the following manner.

A piece of polyurethane foam specified below is made ready for filling under compression into the fuel container 1. It has a cell number of 35 to 40/inch, a hardness of 17 to 23 kgf, and an apparent density of 0.034 g/cm^3. It is three times as long as the lateral length (L_1) of the container 1, and it is almost as wide as the longitudinal length (L_2) of the container. Needless to say, the direction of L_1 coincides with the direction of the minor axis (a). In other words, this polyurethane foam is to be compressed in its longitudinal direction.

It is important that the polyurethane foam be compressed uniformly when it is filled into the container. Uneven compression may give rise to locally collapsed cells and wrinkles along which the liquid in the container flows. In this state the most advantageous results are not obtained. To accomplish uniform compression, the polyurethane foam is filled into the container along guides attached to the inside of the container. The guides (not shown) are made of fluoroplastic to ensure smooth filling. In this embodiment, the guides are in the form of flexible thin plate of fluoroplastic attached to the inside of the container.

When the polyurethane foam 5a has been uniformly filled into the container, the compressed polyurethane foam is in the state as shown in Fig. 3. That is, individual cells are thinned and compressed in the direction of the minor axis (a).

The polyurethane foam 5a is filled into the container through the side 6 (shown in Fig. 1), which is closed afterward.

In this embodiment, the polyurethane foam 5 is filled into the container while it is being compressed. In another embodiment, it is possible to fill the container with previously compressed polyurethane foam. In this case, compression may be accomplished by thermal compression. Thermal compression, however, has a disadvantage that compression takes place more in the outer part in contact with the press than in the core. This leads to uneven compression and the incompletely compressed part of the foam permits the liquid to pass more than the completely compressed part. This is detrimental to the uniform discharging. Therefore, it is necessary to choose a suitable method for compression according to the properties of the liquid to be held in the container.

The compression of the polyurethane foam and the filling of the compressed polyurethane foam into the container are carried out in the following manner. (Compression is in the direction of the minor axis (a) of the unit cell constituting the polyurethane foam, as shown in Fig. 2.)

Fig. 4 is a perspective view showing a jig used for compressing and filling the polyurethane foam in one embodiment of the present invention. There is shown a frame 10 in which the polyurethane foam 5 is fitted. This frame 10 is provided with three pushers. A first pusher 11 is arranged in the lengthwise direction of the frame 10. The polyurethane foam 5 is placed in the frame 10 such that the direction of the minor axis of the unit cell is perpendicular to the surface of the pusher 11 and the direction of the major axis of the unit cell is vertical.

With the polyurethane foam placed in the frame as mentioned above, the first step begins. That is, the first pusher 11 is moved in the direction A so that the polyurethane foam 5 is compressed in the direction of the minor axis (a) until the pusher 11 reaches the position P, as shown in Fig. 4. The compression ratio is about 1/3.

In the first step, it is important that the polyurethane foam be compressed uniformly. Locally concentrated compression will give rise to locally collapsed cells which form wrinkles. Such wrinkles cause the liquid in the container to flow along them. Thus uniform compression is important for good results.

Uniform compression is ensured by the guides 13 of fluoroplastic film attached to the inside 12 of the frame 10, as shown in Fig. 4.

In this embodiment, the first step of compressing the polyurethane foam 5a is followed by a substep of slightly adjusting the amount of compression in the direction B horizontally perpendicular to the direction of compression in the first step. This substep is accomplished by the aid of the second pusher 14.

In the second step, the compressed polyurethane foam is pressed by the third pusher 15 in the direction C vertically perpendicular to the direction of the compression in the first step. In the final step, the compressed polyurethane foam 5a is moved from the frame 10 into the container 20 placed under the frame 10. In this way, the polyurethane foam is filled into the container 20.

Fig. 5 is a side view showing how the final step shown in Fig. 4 is carried out. There are shown sliders of fluoroplastic film 22 suspending on the inside 21 of the container 20. They ensure smooth filling of the compressed polyurethane foam 5a into the container 20.

As mentioned above, the method comprises a first step of compressing the polyurethane foam in the direction A in the frame 10 along the guide 13 of fluoroplastic film, an optional substep of slightly adjusting the amount of compression in the direction B (which is horizontally perpendicular to the direction of compression in the first step) so that the compressed polyurethane foam fits in the container, a second step of pressing the polyurethane foam in the direction which is vertically perpendicular to the direction of compression in the first step, and finally pushing the compressed polyurethane foam (in the direction C) into the container along the sliders 22 of fluoroplastic film. Thus the polyurethane foam is uniformly compressed and filled into the container.

The polyurethane foam filled into the container is compressed in the direction of the minor axis (a) of the unit cell as shown in Fig. 3. Being uniformly compressed without wrinkles, the polyurethane foam prevents the sloshing of liquid and produces a strong capillary action.

Fig. 6 is a perspective view showing the jig used in the second embodiment. There is shown a frame 30 in which the polyurethane foam 5 is fitted. The frame 30 is provided with four pushers. A first pusher 31 and a second pusher 32 are arranged in the lengthwise direction of the frame 30. The pushers 31 and 32 are provided with extended parts 31a and 32a, respectively. It is these extended parts which actually compress the polyurethane foam. They should preferably be coated with teflon® so that their surface has a low coefficient of friction.

At first, the polyurethane foam 5 is placed in the frame 60 in such a manner that the minor axis of the unit cell is perpendicular to the surfaces of the pushers 31 and 32, as in the case of the foregoing embodiment. The pusher 32 is moved to the position G, and then the pusher 31 is moved (against the pusher 32) to the position E, so that the polyurethane foam is compressed between the pushers 31 and 32. With the polyurethane foam compressed, the pushers 31 and 32 are moved to the positions F and G, respectively. The distance between the positions F and G is equal to that between the positions G and E, and the posi-

tion F is the position where the pusher 32 was originally present.

In this state, the container 40 is engaged with the extended parts 31a and 32a. Finally, the third pusher 33 is moved downward to push the compressed polyurethane foam into the container 40 along the extended parts 31a and 32a. Fig. 7 is a sectional side view showing how the compressed polyurethane foam 5a is pushed downward into the container 40 by the third pusher 33.

Incidentally, the fourth pusher 34 has a flat plate 35 which penetrates the extended part 31a. This flat plate 35 is intended to press down the top of the polyurethane foam 5 before-hand. It is actuated before the step of compressing the polyurethane foam 5. It may be necessary depending on the size and properties of the polyurethane foam to be compressed.

Claims

1. A polyurethane foam-filled container, filled with polyurethane foam of open-cell structure, characterised in that the foam filling is in a state of compression, substantially in the direction of a minor axis of unit cells of the foam.

2. A container according to claim 1, wherein the polyurethane foam has a compression ratio of 1/2 to 1/10 and a cell number of 20 to 100/inch (8 to 40/cm).

3. A container according to claim 1 wherein the polyurethane foam has a compression ratio of 1/1 to 1/5 and a cell number of 50 to 100/inch (20 to 40/cm).

4. A container according to any one of the preceding claims wherein the polyurethane foam is filled in a mechanically compressed state.

5. A container according to any one of the preceding claims in which the foam is substantially uncompressed in the direction of the major axis of the unit cells.

6. A method of making a container filled with open-cell polyurethane foam, characterised by compressing the foam, substantially in the direction of a minor axis of unit cells thereof.

7. A method according to claim 6 comprising a first step of compressing the foam to a predetermined extent along guides in the direction of the minor axis of the unit cells, and a second step of moving the compressed polyurethane foam in the direction perpendicular to the direction of compression in the first step, thereby filling the compressed polyurethane foam into a container along at least one guide piece positioned by the inner wall of the container.

8. A method according to claim 7 which further comprises a sub-step of adjusting the amount of compression in the direction horizontally perpendicular to the direction of compression, said sub-step following the first step.

9. A method according to any one of claims 6 to 8 wherein the guides and guide pieces have low-friction surfaces.

10. A method according to claim 9 wherein the low-friction surface is a fluoroplastics surface.

11. Use of a container according to any one of claims 1 to 5, for containing liquid.

FIG.1

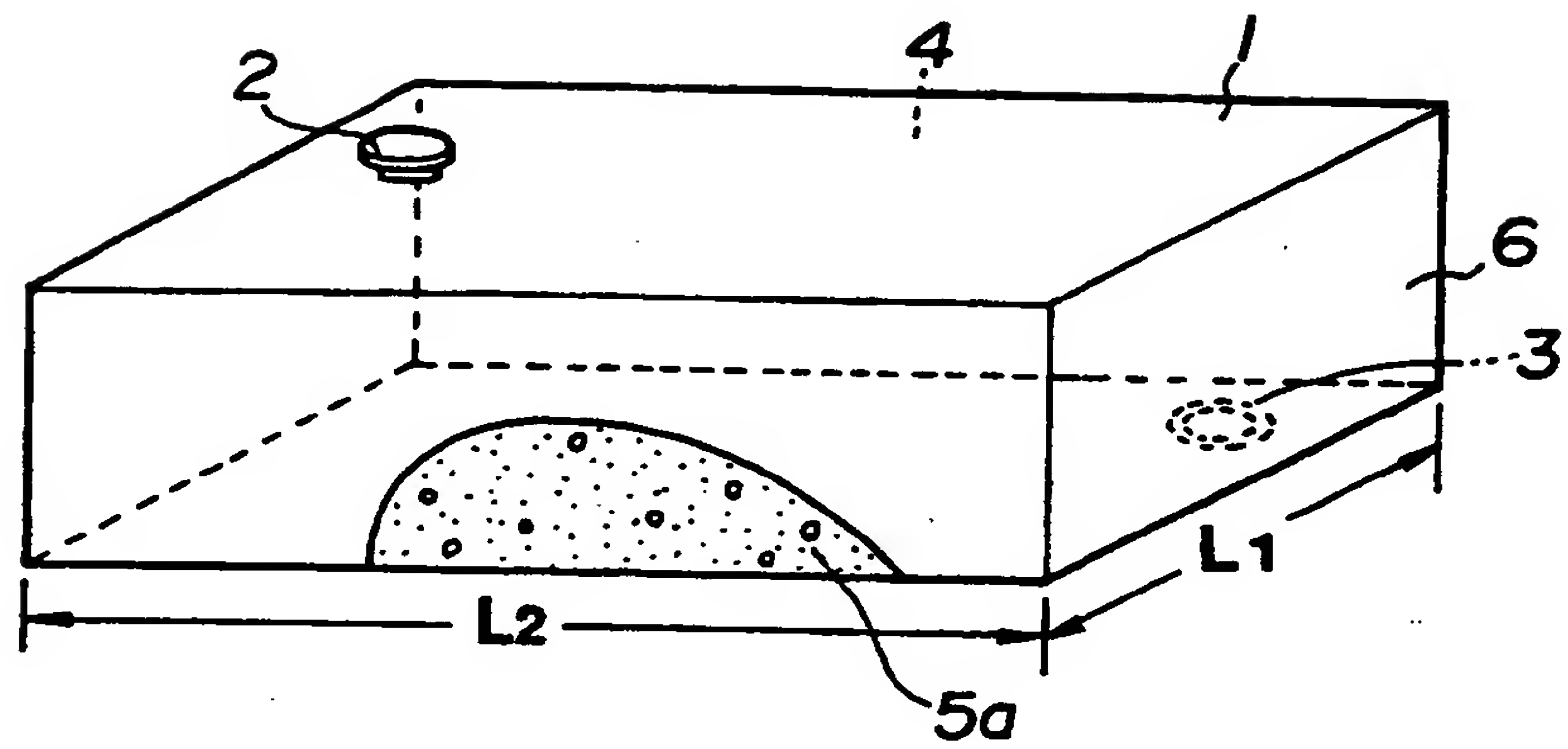


FIG.2

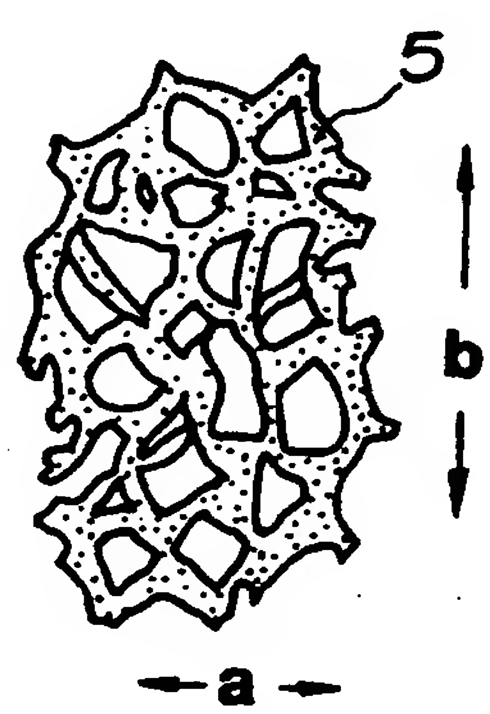


FIG.3

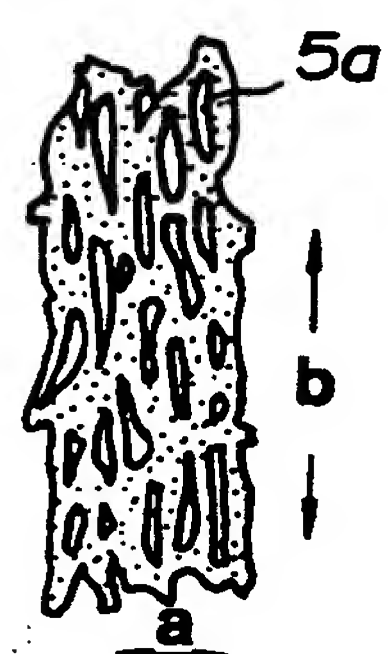


FIG. 4

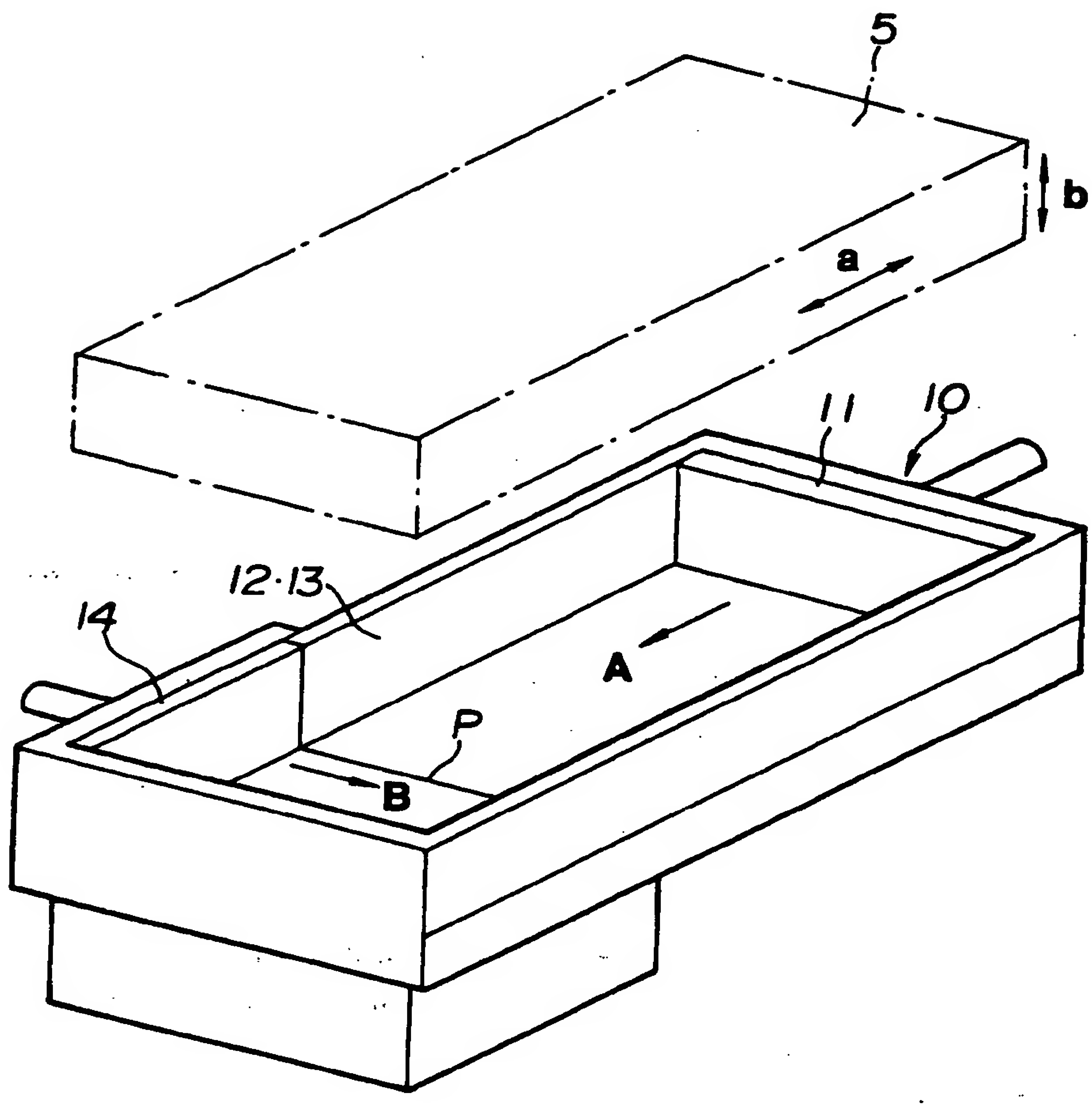


FIG.5

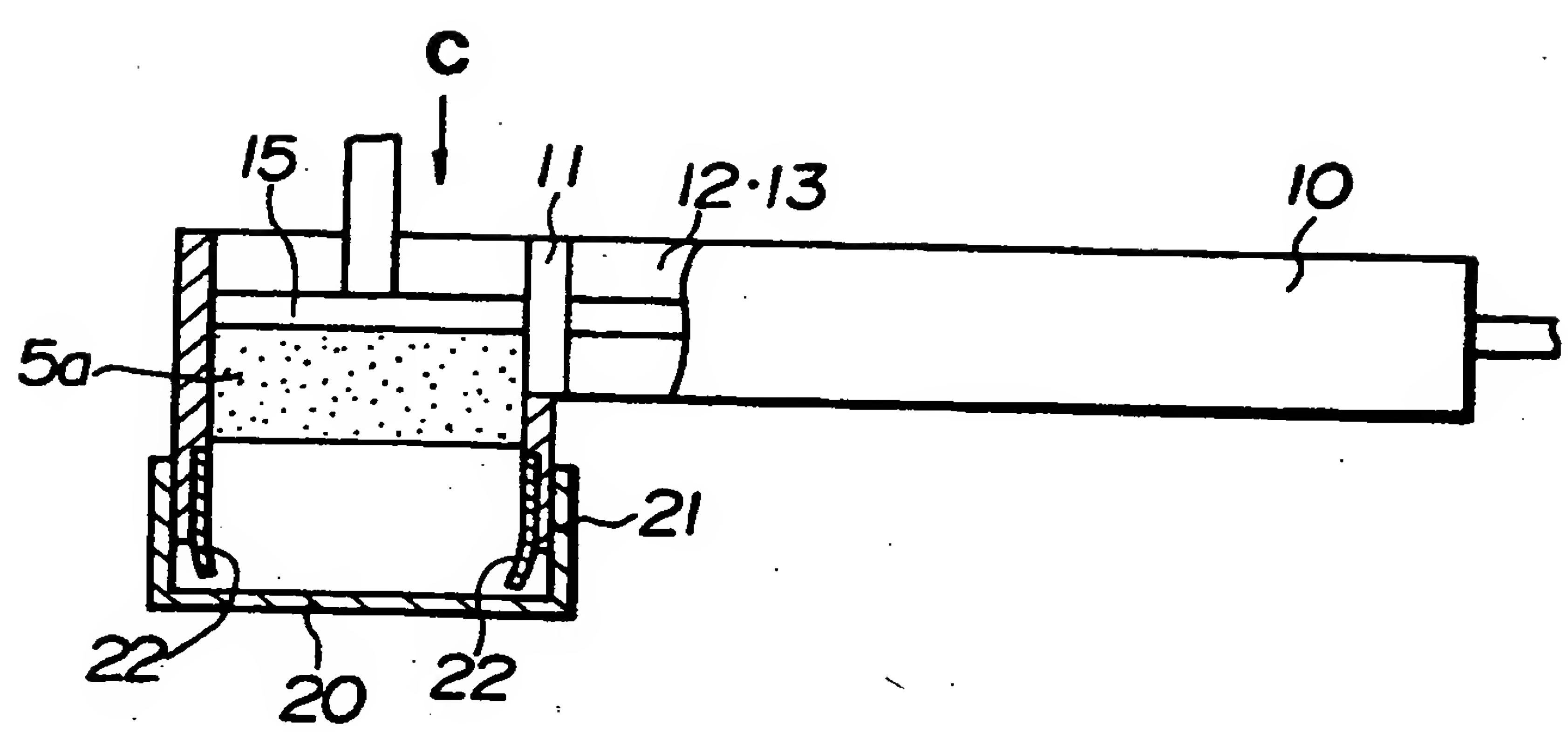


FIG.6

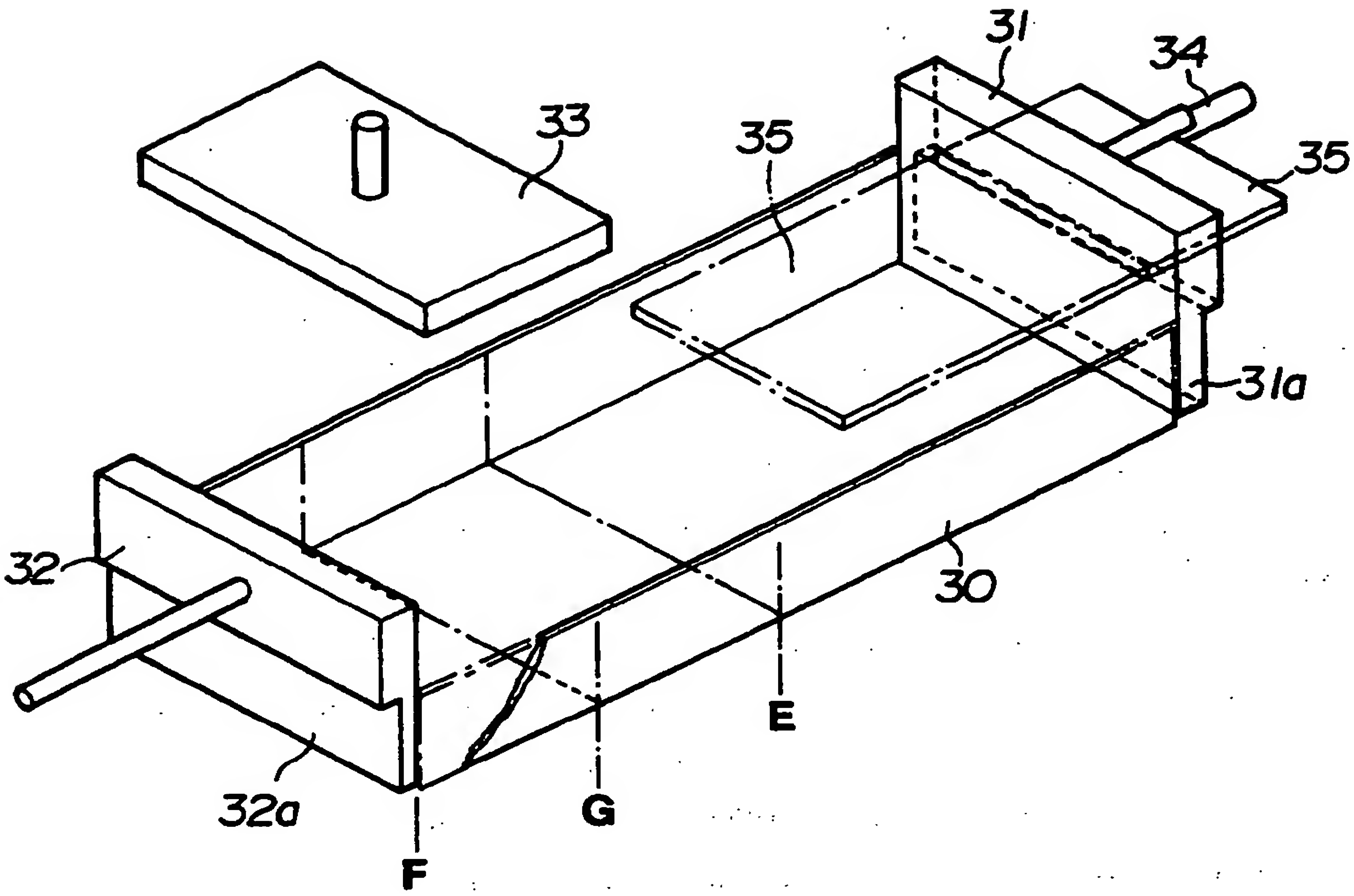
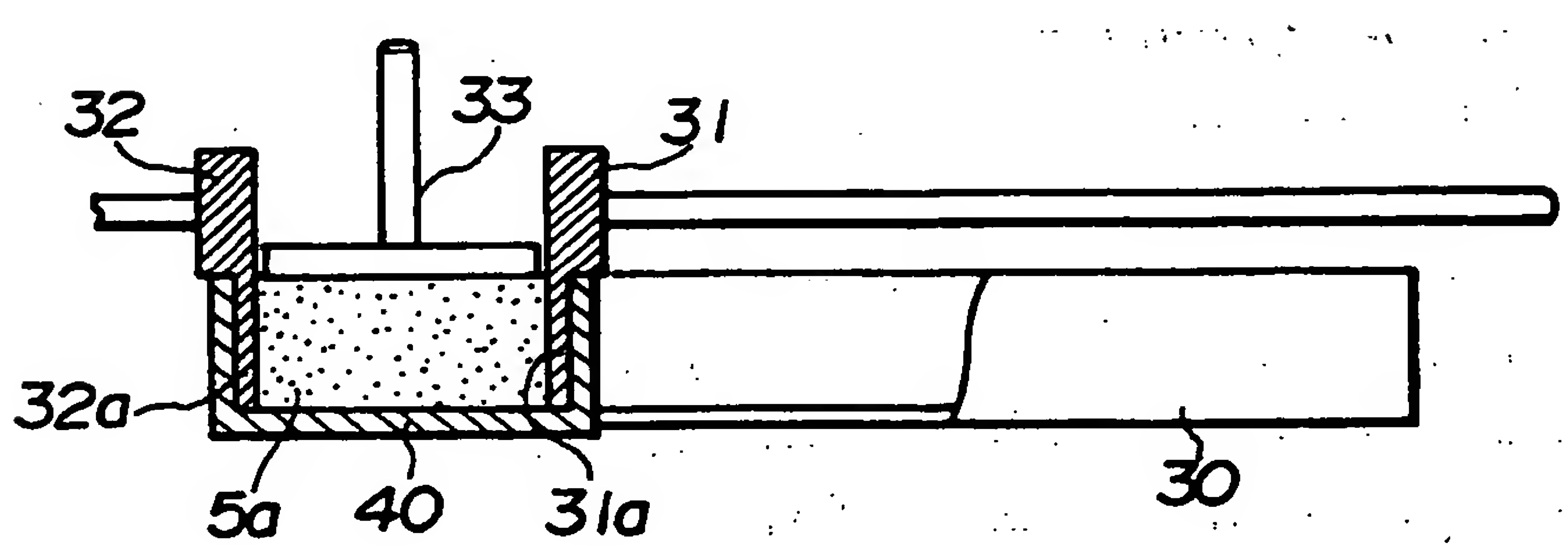


FIG.7



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(54) **Polyurethane foam-filled containers and methods of making them.**

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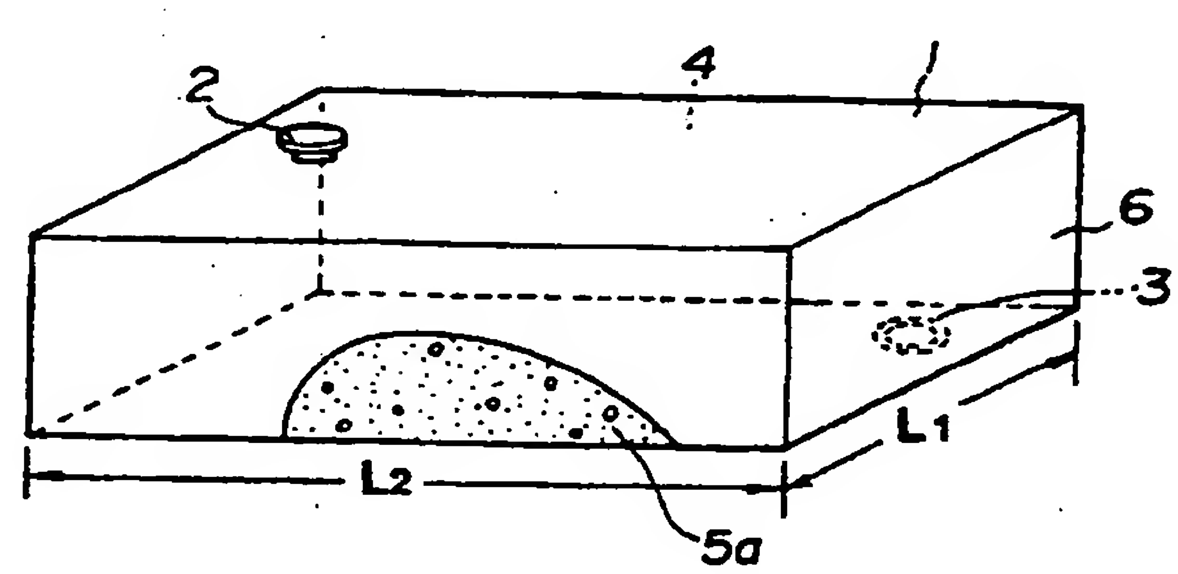
FIG.1



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EUROPEAN SEARCH REPORT

Application Number
EP 92 30 5623

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
P,X	EP-A-0 488 829 (CANON K.K.) * column 3, line 6 - column 5, line 44; claim 3 *	1,6,11	B41J2/175 B65D81/26
A	US-A-4 929 969 (MORRIS) * column 6, line 1 - line 13; figures 1,3,7,8 * * column 8, line 38 - line 48 *	1,6,11	
D D,A	US-A-4 771 295 (HEWLETT-PACKARD COMPANY) & EP-A-0 261 764 (HEWLETT-PACKARD COMPANY) * column 2, line 8 - line 11; claim 7 *	1-11	
A	PROCEEDINGS THE SIXTH INTERNATIONAL CONGRESS ON ADVANCES IN NON-IMPACT PRINTING TECHNOLOGIES October 1990, ORLANDO, FLORIDA U.S.A. pages 498 - 507 , XP000222277 BRIAN G. MORRIS 'Novel material used as an ink reservoir for Drop On Demand printheads' * the whole document *	1-11	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-3 708 330 (G.B.HARR) * column 3, line 13 - line 47 * * column 7, line 6 - line 15; figures 1-7 *	1,2,3,4,6,11	B41J B65D
A	EP-A-0 419 192 (CANON K.K.) * claim 1; figure 1 *	1,5,6,11	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 JANUARY 1993	JOOSTING T.E.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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